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## THE PHYSIOLOGICAL EFFECTS OF ROUTE MARCHING.

*Studien zu einer Physiologie des Marsches.* By Dr. Zuntz, Professor of Physiology in the Royal Agricultural College, Berlin, and Dr. Schumburg, Oberstabsarzt 1st Cl. and Privatdocent, Hanover. (Vol. vi. of the *Bibliothek von Coler, Sammlung von Werken aus dem Bereiche der Militär-medizinischen Gebiete*. Edited by O. Scherning.) Pp. viii + 361, and one chart. (Berlin: August Hirschwald, 1901.)

THE "Bibliothek v. Coler" was commenced in March last to celebrate the seventieth anniversary of the birth of Generalstabsarzt Alwin v. Coler, who held the post of Director-General of the Army Medical Service in Germany from the year 1889 until his death in September last. V. Coler was intimately associated with the development of that service ever since its foundation in 1868, and it may truthfully be said that the fine *esprit de corps* which exists in it to-day, and which is characterised by a determination to maintain a high standard of culture and scientific attainment amongst its members, is due to his influence. The collection of works which have been called after him admirably demonstrates what this influence meant. It is edited by Generalarzt Otto Scherning, v. Coler's colleague and ally, and some twenty-six volumes are already announced. They are an excellent expression of the scientific work of the German Military Medical Service, as carried out under v. Coler's guidance and inspiration, as well as of the intimate relationship that exists between army doctors and the teaching professors in Germany.

The authors of the volume under review are well known. Prof. Zuntz's previous work on metabolism is authoritative, and Dr. Schumburg has acquired a wide reputation for original investigations on a variety of military medical subjects. The volume is a record of careful and elaborate observations, made by them, on the physiological effects of route marching. In some of their experiments, notably those involving complicated chemical analyses, they were helped by Prof. Munk, Dr. Nichter, Dr. Frenzel and others.

The introductory chapter is an historical sketch of previous anatomical and physiological work in the same direction from the time of Fabricius de Aquapendente, Gassendi and Borelli to the more modern investigations of Marey, Vierordt, Braune and Fischer. This *résumé* is fairly complete and interesting, but the work done in England is not well represented.

The remaining chapters are an account of the authors' own observations and are of exceptional interest and merit. Five students of the Kaiser-Wilhelm-Academie (formerly known as the Friedrich-Wilhelms-Institut), the cadet school for medical students destined for the military medical service of their country, volunteered for the experiments. During April, May, June and July they marched, at frequent intervals, a distance of 24.75 km. without altering the route or the pace. The marches were commenced, as a rule, at 7 o'clock in the morning, occasionally at 5 o'clock, and two halts were made, one

of ten minutes and the other of half an hour for breakfast. The service uniform and accoutrements were worn, and, with the exception of the weather, the only variation in the condition of the marches was in the weights carried. In fact, the experiments were conducted to determine the limit of weight which the soldier can carry without interference with his capacity for striking, and striking hard, at the end of a day's march. Both authors were members of a German War Office committee appointed to decide this point by physiological experiment in 1894, and, although the observations recorded in this volume were conducted during that year, they do not appear to have been made public until now.

It would be difficult in a short review to detail all the points of interest in the volume. They are many. Several of the more important scientific details are contained in tables interspersed throughout the text or brought together in appendices. If the headings of the columns of figures in these tables indicated more precisely what the figures represented, the physiologist would be able to study the records and draw his own conclusions from them without much difficulty. Unfortunately, this is not always the case, and it is often impossible to follow the tabulated records without closely reading the text; and, as is apt to be the case in German works of this kind, the latter is full of argument, comparisons and historical comments which tend to confuse the simple statements of fact. At the same time, it is only fair to say that these interpolations are well-balanced criticisms of the results of the experiments, and that the authors' conception of their own laborious work is dignified and modest in the extreme.

The extent of this work may be estimated from the fact that immediately before and after each march, sometimes during the march and on days of rest, careful examination was made of all the organs and functions of the body that were likely to be influenced by the carrying of a heavily loaded knapsack. This included sphygmographic tracings, enumeration of blood corpuscles, estimation of the specific gravity of the blood, experiments on the reaction of muscles and nerves, measurements of vital capacity and records of variations in urinary constituents. These formed one series of observations only. A second and more complicated series was carried out, in the case of two of the students only, in order to determine the effect of the marches on metabolism, and one must be content to present here a few of the practical results of these investigations without attempting to exemplify the full extent and scope of the work.

After graduated marches with lighter weights, the students were made to carry knapsacks with loads of 22, 27 and 31 kg., and the physiological effects of the lightest, intermediate and heaviest of these loads were compared.

The general condition of the students improved, excessive fat disappeared, while the body-weight was reduced by 1.5 to 3.5 kg. The sphygmographic tracings showed that cardiac systole was prolonged and diastole shortened as the weights carried were increased. This is exemplified by the use of a quotient derived from the formula  $\frac{D}{S}$ , where D represents the durations of the diastole and S that of the systole in

1/100ths of a second. The mean of the observations made this quotient = 1.73 with a 22 kg. load, 1.58 with 27 kg., and 1.47 with 31 kg., while the lowest quotient of  $\frac{D}{S}$  recorded during rest was 1.88 and the highest 3.28.

The effect of heavy marches on the systole and diastole of the heart was, therefore, as the authors express it, undoubted. They attribute the result to fatigue of the cardiac muscle and consider that, if the load is raised beyond 31 kg., permanent damage to the heart may result. They also noted that the pulse increased to 140 and 150 beats per minute and that diastole became marked as the quotient of  $\frac{D}{S}$  approached unity.

Another important and unexpected result was that in a series of eighty-nine observations the cardiac area of dulness showed marked increase in sixty-four and the hepatic area in sixty-seven instances after the march. This increase was noted in 56 per cent. of the observations after a march with 22 kg., in 70.4 per cent. with 27 kg. and in 87.5 per cent. with 31 kg.

Still more important is the observation that the increase in the area of dulness was due to dilatation of the right and not of the left side of the heart, and that it is produced by a general stagnation of the venous circulation. The authors designate the phenomenon "march dilatation of the right side of the heart."

These observations on the cardiac function are new and well worth noting. They have special significance for the military medical officer, as they throw a new light on the condition known as "disordered action of the heart," which is a common sequel of military training and the cause of a considerable amount of invaliding in the British Army.

The observations on other organs and functions did not produce quite such interesting or positive results. The specific gravity of the blood was only increased by .006 and the red blood corpuscles by 9 per cent. after the heaviest march. An apparent increase of 43 per cent. in the white corpuscles was due to polynuclear cells being carried into the circulation from the walls of the larger veins, in consequence of increased cardiac action; but the blood resumed its normal condition on the day following the march.

The vital capacity of the lungs was studied by means of an experimental gas meter, into which a number of expirations was made in succession, and the volume indicating vital capacity determined by dividing the total record by the number of expirations. This was considered more accurate than records given by Hutchinson's spirometer. Sixty-nine observations were made during marches with loads and eighty-nine during marches without loads. The practical result was that, up to a certain point, the graduated training of the soldier increased his vital capacity, but that a marked diminution occurred in marches with the heaviest loads, this serious result being associated with the dilatation of the heart and liver and the venous stagnation already noted. Another practical observation was that the increase in frequency of respiration, which is invariably associated with exercise, gradually falls to normal during halts, but that when dilatation of the right side of the heart had become well

marked, this increase remained as high as 40 per cent. above the normal even after a halt of 30 minutes. The authors conclude that frequency of respiration exceeding 28 per minute, or 75 per cent. increase on the normal with a gradual fall to 30 per cent. above normal after a quarter of an hour's halt, is the limit which can be borne by a soldier of average strength without breakdown.

The observations on the effect of the marches on body temperature are comparatively brief, but the subject of the regulation of heat and the calorific value of the work done forms a complicated series of calculations and experiments introduced into the chapters which are devoted to the study of metabolism. The authors estimate that the heat production of the work done in marching is sufficient to raise the body temperature 1° C. in 8.7 minutes. In the direct observations there was an actual increase of temperature of 1° to 1° 5' C. only, after the heaviest marches. As the surface cooling resulting from the evaporation of sensible and insensible perspiration plays so important a part in maintaining heat equilibrium, the authors rightly emphasise the importance of attention being paid to the material and nature of the soldiers' clothing with a view to avoiding interference with this function of the skin.

Experiments on the influence of the marches on the nervous system and on muscles were unsatisfactory. Observations were made on the "reaction period," and ergographic tracings were taken with Mosso's apparatus. The results in both cases were inconclusive and conflicting, weather, individual disposition, auto-suggestion, all helping to bring this about. An attempt was also made to estimate the effects of the marches on the nervous system by some ingenious memory tests, but they were so influenced by the drowsiness consequent on the early morning start that the after results were quite inconclusive.

Some interesting facts are recorded in connection with the renal function. Notwithstanding the great loss of water by perspiration, there was no increase in the specific gravity of the urine. Thus the average specific gravity in 150 observations before the march was 1023.6, and after the march 1021.7. This convinced the authors that marching has a diuretic effect, and they recall similar observations by Oertel and Henschen. Their observations on albumin in the urine are also contrary to the general impression, an impression no doubt derived from the observations of Albu and of Macfarlane, that during hard physical exercise transient albuminuria occurs. Zuntz and Schumburg found nothing of the kind amongst their five students, and they point out that Benedicenti had made similar observations on soldiers.

The series of observations and experiments on metabolism includes analysis of nitrogenous waste, respiratory changes, calorific value of the work performed, and the regulation of the body temperature. The observations are of an elaborate and complicated character, and only two of the five students were submitted to experiment. The chief practical results may be briefly noted.

The elimination of nitrogenous products both by the skin and kidneys was not markedly influenced by the marches. When increase did occur, it occurred on the day following the march, and not during or immediately

after the march. The calculation of elimination by the skin was made by careful analysis of the underclothing. The average amount was found to be 284 mg. per litre of perspiration, and as the perspiration increased the proportion of nitrogen eliminated diminished. Thus 2069 grms. of perspiration contained 0.308 per cent. of nitrogen, while 3447 grms. contained only 0.243 per cent. The number of observations on this point was few, and the results suggest the need of further investigation.

In estimating the respiratory changes, the authors made use of the "*tret-werk*," a rolling platform worked by machinery so as to move backwards at the same rate as the individual walking upon it moves forwards. In this manner he remains constantly at the spot where the apparatus for measuring the respired air is fixed. The two students marched on this "*tret-werk*" for six to eight minutes immediately after each march, and for eight to ten minutes during periods of rest, with and without the knapsack. The influence of the marches on the respiratory changes was determined by the "respiratory quotient," *i.e.* the quotient derived by dividing the volume of CO<sub>2</sub> expired by the volume of O inspired. This quotient is equal to unity in the case of herbivorous animals, who obtain their carbon from carbohydrates only and not from hydrocarbons. In carnivorous animals the necessity of using some of the oxygen for the oxidation of the hydrogen in the hydrocarbons, which they consume, diminishes the volume of CO<sub>2</sub> expired in proportion to the oxygen inspired, and the quotient in their case is consequently expressed by a fraction of unity. The authors make use of this fact and show that the "respiratory quotient" is a constantly diminishing fraction after heavy marches. In other words, the carbohydrates are very quickly used up, leaving the fats only as energy-producing material. They conclude from this that, in continuous heavy marching, the carbohydrates consumed in the rations are not sufficient to replace the waste, and that a day's rest is required after every three days' marching to enable the body to recover its normal power.

There are many other points in this volume that are suggestive and of practical importance in military training and in military operations, and it must be regarded as one of the most important works that have been published with reference to several questions that arise in connection with military hygiene. The German military authorities, at any rate, have accepted the conclusions as authoritative, and the regulations bearing upon marching and physical training in Germany are evidently inspired by them.

W. G. M.

#### LIVES OF THE HUNTED.

*The Lives of the Hunted.* By Ernest Seton-Thompson. Pp. 360. (London: Nutt, 1901.) Price 6s. net.

"LIVES OF THE HUNTED" is practically a second volume to the first of three books noticed in a general review of Mr. Seton-Thompson's work lately published in NATURE (p. 25), "Wild Animals I have Known." When a book has earned a well-deserved success, the temptation to the author to write another on

the same lines is strong. But sequels of the kind are seldom as good as the originals, and this is no exception to the rule.

Mr. Thompson is so well up in his subjects that nothing that comes from his pen or pencil can be without interest. The full-page illustrations—more particularly those of the bears in the Yellowstone Park and the big-horn ram facing the wolves—are excellent; but, with some exceptions, neither the letterpress nor the marginal sketches are quite on the level either of the book named above or of the "Biography of a Grizzly."

Unfortunately, too, the little pitted speck noticeable in his earlier writings—more especially in "The Trail of the Sandhill Stag"—a tendency to a rather sickly sentimentality, has grown to disfiguring proportions, and in his last production is a serious blemish.

"The preservation of our wild creatures," to which the book is dedicated, is a worthy object. But it is doubtful whether it is likely to be substantially helped by suggestions, if not actual arguments, which, in spite of Mr. Thompson's assurance that he does "not champion any theory of diet," can only, if pushed to their logical conclusions, mean that mankind is in duty bound to give up eating meat and turn vegetarian. The sneer at "the Saxon understreak of brutish grit, of senseless, pig-dogged pertinacity," which made the old huntsman Scottie stick to the trail of the great ram until the coveted head and horns were his—the race-quality, by the bye, which has helped more, probably, than any other to raise the United States as well as England to the positions they hold among the nations—may appeal, perhaps, to some of his readers, but to others less emotional it may seem a little silly.

"Wolfish human brute" is rather a "brutal" summing-up of the character of the plucky old stalker, whose actual name is given, to come from the pen of a writer who, according to his own account, was not, in trapping days, foolishly over scrupulous.

But when he leaves "gush" and sentiment behind him, and, warming to his work, writes in the bright, unpretentious style which is more natural to him of the things he has seen and known, Mr. Thompson is well worth reading.

"Johnny Bear," the third story in the collection, is a simply-written and charming description of the ways of the bears he studied closely in the Yellowstone Park, and even more delightful, perhaps, is the account he gives of the home and habits of the fairy-like kangaroo rat,

"the loveliest, daintiest fawn-brown little creature ever seen in fur," with "large beautiful eyes . . . innocent orbs of liquid brown; ears like the thinnest shells of the sea, showing the pink veins . . .; hands the tiniest of the tiny, pinky-white and rounded and dimpled like a baby's."

Sentiment notwithstanding, Mr. Thompson dug out and explored, and in the margin gives a plan of the little creatures' underground establishment, which was safely protected from the attacks of coyotes and other miscreants by the spiked leaves of an overshadowing "Spanish bayonette" bush. It is engineered on much the same general lines as the breeding nest of a mole, with

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